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Survey of the non-native plant species in the Spanish Iberia in the period 1975-2002

Abstract

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A bibliographic search was carried out to make an updated catalogue of the plant species introduced and naturalized in the Spanish part of the Iberian peninsula. The number of records reported in the period 1975-2002 amounted to 170 plant species. The results were categorized according to botanical families and geographical origin. The status of these naturalized species and their distribution within the autonomous regions of the Spanish Iberia were also studied.

Introduction

One of the issues arising from research on non-native plant species is the scope of this category. When a plant species is categorized as non-native the author refers to its presence in a geographical area that constitutes a political unit regardless of the fact that this may not be equivalent to a homogeneous territory or ecological unit. The case of Spain is a clear example of this. Two countries, Spain and Portugal, are in the Iberian Peninsula, but the Spanish nation consists not only of the Spanish Iberia but also of its overseas territories, the Balearic and Canary islands.

Nowadays, intensive trade and the constant flow of people have resulted in a large plant transfer crossing frontiers and geographical boundaries. For example, it is reported that the introduction of non-native plant species in California for the last 150 years has seen an exponential growth similar to the increase in human population (Randall & al. 1998).

During the 20th century the way in which the introduction of new plant species is regarded has changed progressively. In the first half of the 20th century only those species interfering with human activity or causing economic losses were perceived as a problem. This perception has become broader and nowadays the effect of the introduction of a new species is also related to the environment of the new site. However, in the past it was believed that non-native plants would not be able to thrive without man's help because, at equilibrium state, the land vegetation would prevent their establishment. More recently, Vitousek & al. (1997) have assessed the potential of non-native species for interacting with the composition and performance of the ecosystem and for producing ecological change.

Another remarkable aspect of the research on non-native species is the wide range of names used to refer to the fact that a plant species has been introduced in a new site. For

example, some of the epithets/names applied in the literature to non-native plants are: non-indigenous, allochthonous, exotic, alien, adventitious, invasive, naturalised, xenophyte, environmental weeds, resident, new-native, etc. However, these names are not necessarily synonymous. Depending on the context, names can mean different things. For instance, according to Tutin & al. (1964), a plant species is naturalized when"... the plant has been established in a single station for at least 25 years or is reported as naturalised in a number of widely separated localities". The epithets: 'invasive', 'non-native' and 'allochthonous' are used (Richardson & al. 2000) with this meaning, although the concepts may not be exactly equivalent.

According to Richardson & al. (2000) the succession of stages following the arrival of a non-native species are: I) introduction, II) naturalization, III) invasion, and IV) incorporation. In the introduction stage –essentially its arrival- the species crosses geographical boundaries with the help of an introducing agent –usually man- and succedes in establishing a new adult population which survives. In the event of failure the species then disappears (ephemeral species). The second stage, 'naturalization', is reached when the species overcomes biotic and abiotic barriers to survival and reproduction. Subsequently, the initial population reproduces and increases its size and forms a self-perpetuating colony. The next stage, 'invasion', is characterised by the development of new self-perpetuating colonies and their dispersal to distant sites. The final stage of this process is the incorporation of the new species into the local flora, sometimes in strong competition with one or more native species. However, the sequence outlined above does not always occur as described. Not all the non-native species become invasive, neither are all the invasive species non-native. In fact, only a small number of the non-native species succeed and subsequently spread across a large area, provided that man does not act in opposition to this process. Besides, the character of being invasive can occur in different degrees - more invasive, less invasive.

Models for assessing the invasive capacity of a particular plant species are available currently.

Studies conducted by several authors have shown the importance of non-native species in different countries. According to Fournier (1961), the number of exotic plant species naturalized in France was 479. Westbrooks (2003) reported for the USA about 3800 non-native species, of which 1450 were weeds. In Australia, Virtue & Panetta (2003) reported nearly 300 species naturalized in the period 1971 to 1995. In the case of New Zealand, Williams (2003) estimated the rate of naturalization at 14 species per year. For our neighbouring country Portugal, Almeida & Freitas (2001) found that 184 non-native species were introduced there in the period between 1974 and 1999.

According to Wittenberg & Cock (2001), problems subsequent to the introduction of non-native species can be prevented by the following measures: I) prevention II) early detection, III) eradication, and IV) control. If a non-native species overcomes the prevention measures and its introduction starts accidentally, it is crucially important that this fact is detected early to be able to achieve the eradication or control of the species.

In the case of early detection, an up date to review of what is known about the occurrence of the plant is useful not only to study the species spread - whether it is in terms of area distribution or speed - but also to establish intervention measures. Some of the data that should be included in such a review are the following:

- Date of the first record, not forgetting that the actual arrival date will usually have been prior to this.
- Area concerned.
- Extent and/or intensity of its occurrence, particularly if the introduction has been, for instance, through the use of an allochthonous plant species for land restoration, or by seed contamination. Plant occurrence details are important because, when there is a large amount of plant propagules, the chances of preventing invasion are very low for natural plant communities (Randall & al. 1998).
- Distribution and associated problems

The work presented here is set within the aforementioned research field. The aim of the work was to produce an updated catalogue of the non-native plant species recorded for the Spanish Iberia in the period 1975 to 2002 and to analyse the distribution pattern.

Materials and methods

This study has been restricted in terms of geographical area to the Spanish Iberia, hence species native to Portugal and present in Spain are reported as non-native plants. In terms of time, the limits of the work are given by the period chosen: 1975 to 2002, a period similar to the one studied by Almedia & Freitas (2001) in Portugal.

In this work the occurrence of a non-native plant species was recorded provided that the first record for Spain was dated within the period 1975-2002. An exception to this rule was made in two cases when the only previous information about the species occurrence in Spanish Iberia was: I) herbarium specimens dated in the first 25 years of the XX century and not reported again until 50 years later, and II) species reported as cultivated plants. Non-native species present as garden plants were not included in our catalogue if no other evidence of their presence in Spain as scaped or naturalised was found.

A bibliographic search was conducted in the records of non-native spermatophytes present in the Spanish Iberia and reported as recently-introduced or naturalized. The data concerning scientific name, first record date, record author, occurrence area -autonomous region -, origin and status, if available, were compiled. The search was carried out in botanical Journals and other related literature using as keywords the accepted scientific names and synonyms. For the record date, the date of the first record was used instead of the date of introduction of the species, on the grounds that this is unknown.

The search conducted for this work covered most of the Spanish botanical Journals and Floras (see Appendix 2). The authors cannot affirm categorically that the compilation is fully comprehensive because the literature is very dispersed. Unintentional omissions of records may have occurred.

Once the compilation of data was completed, the records of non-native species were organised according to botanical family, geographical origin and area of detection (autonomous region) in the Spanish Iberia. In some cases, the origin of the species is found in two or more geographical areas, and in others the first record was reported in several regions simultaneously. In these cases, the origins and detection areas were separately recorded in our work.

Table 1. Families with less than 2% of the non-native species introduced in Spain in the period 1975-2002. Between brackets, number of new species reported for Spain.

Amaranthaceae (3)	*Amaryllidaceae* (1)	*Apiaceae* (3)	*Asclepiadaceae* (1)	*Balsaminaceae* (2)
Betulaceae (1)	*Boraginaceae* (3)	*Cactaceae* (2)	*Caryophyllaceae* (2)	*Chenopodiaceae* (3)
Commelinaceae (2)	*Convolvulaceae* (3)	*Cuscutaceae* (1)	*Cyperaceae* (3)	*Elatinaceae* (1)
Gentianaceae (1)	*Haloragaceae* (1)	*Hyacinthaceae* (1)	*Hydrocharitaceae* (2)	*Hydrophyllaceae* (1)
Iridaceae (2)	*Juncaceae* (2)	*Lamiaceae* (1)	*Liliaceae* (1)	*Malvaceae* (3)
Martyniaceae (1)	*Nyctaginaceae* (1)	*Nymphaceae* (1)	*Onagraceae* (2)	*Orchidaceae* (1)
Orobancheaceae (1)	*Phormiaceae* (1)	*Primulaceae* (1)	*Ranunculaceae* (1)	*Rosaceae* (1)
Sapotaceae (1)	*Saxifragaceae* (1)	*Scrophulariyaceae* (1)	*Tetragoniaceae* (1)	*Thymelaeaceae* (1)
Valerianaceae (1)	*Verbenaceae* (1)			

Results

The catalogue of the non-native plant species introduced in Spain in the period 1975-2002 is given in Appendix 1. The results of the statistical analysis performed to provide a summary of this catalogue are shown in Figures 1, 2 and 3 and in Table 1.

The results of this work show that the number of non-native species introduced in Spain from 1975 to 2002 is 170, equivalent to a rate of 6 new species per year. This value is close to the one reported by Almeida & Freitas (2001) for Portugal: 184 new species in the period 1974-1999.

The non-native species reported in our catalogue belong to 50 botanical families. Most of the reported species are from only three families: *Asteraceae*, with 37 species (⇔ 22% of the total number of introduced species), *Poaceae*, with 34 species (⇔ 21%), and *Solanaceae*, with 10 species (⇔ 6%) of which 9 are in the genus *Solanum*. The *Solanum* genus exhibits the highest frequency of introduced species. The analysis of the results for botanical families is consistent with the data reported by Almeida & Freitas for Portugal.

The families most represented there were also *Asteraceae* and *Poaceae*, and *Solanaceae* was 4th in the ranking. Relative frequencies of the different families reported in this work are shown in Figure 1. Families exhibiting frequencies lower than 2% - overall representing 37% of the introduced species- are categorized as 'Other families' in Figure 1.

However, they are separately reported in Table I with figures for the respective number of new species. There were 27 families with only 1 introduced plant species.

Figure 2 shows the analysis of the results as a function of the species origin. The most frequent origin is America, representing 46% of the introduced species. Among the areas closer to Spain are North Africa (10 species), the Mediterranean area (13 species) and Portugal (8 species).

As regards the status of the species compiled in this work, the most frequent category is weeds. In fact, 58% of the species pool are recognized as weeds in the literature (Holm & al. 1979) and/or in their areas of distribution in Spain. Notable weed genera listed in our catalogue are: *Amaranthus, Amsinckia, Leptochloa, Solanum, Heteranthera*, etc. It should be noted that some of the species categorized as weeds were deliberately introduced in

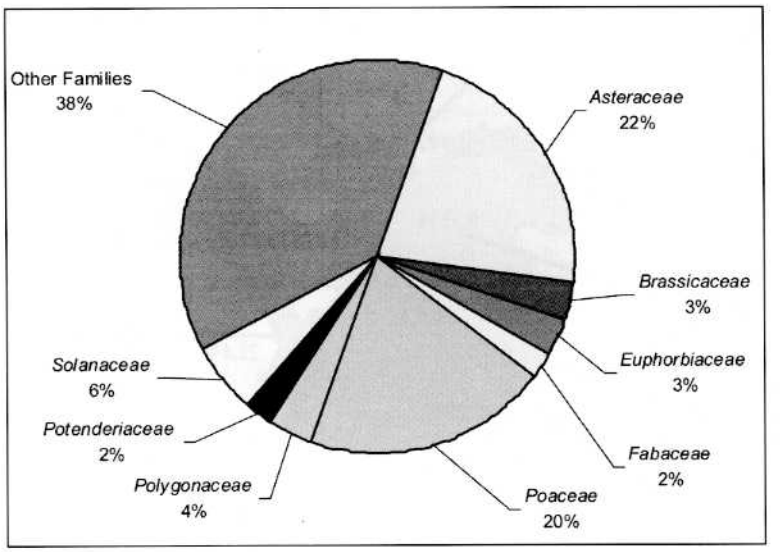

Fig. 1. Relative frequency (%) of non-native species introduced in Spain in the period 1975-2002, categorized according to botanical family.

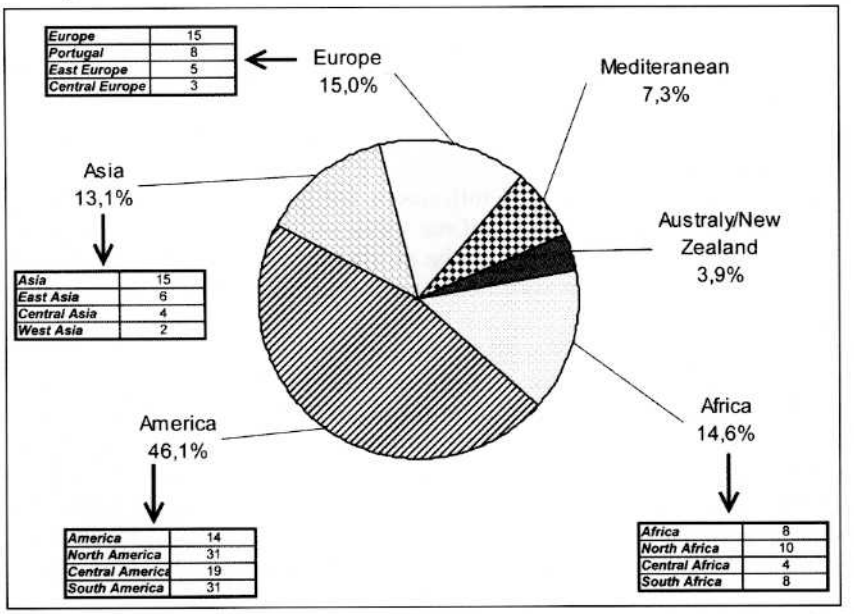

Fig 2. Relative frequency (%) of non-native species introduced in Spain in the period 1975-2002, as a function of the species origins. The adjacent tables show the number of new species allocated to geographical areas.

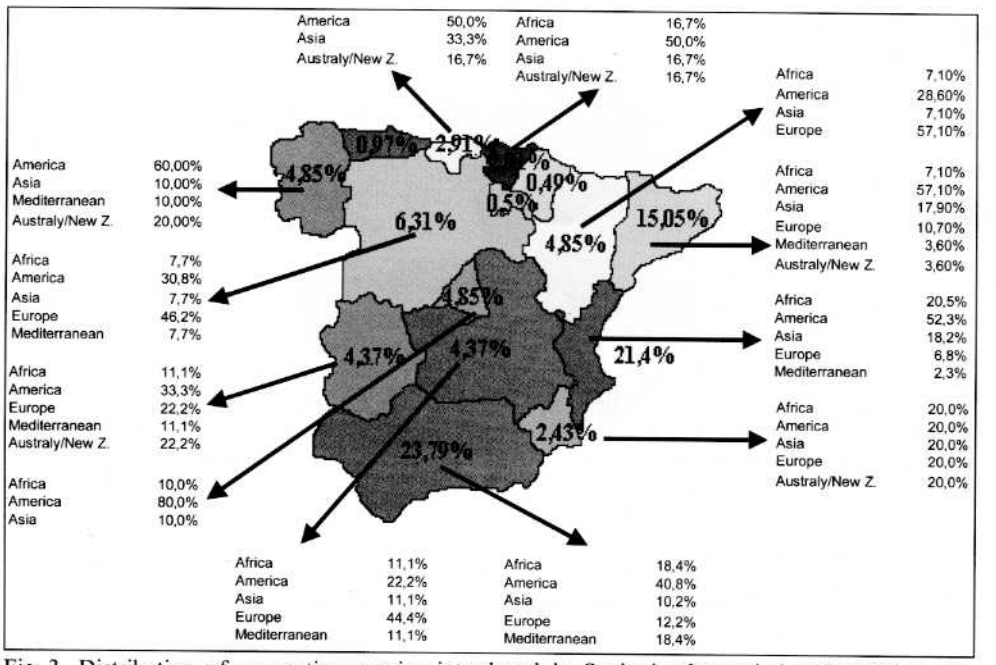

Fig 3. Distribution of non-native species introduced in Spain in the period 1975-2002 in the autonomous regions. The values on the map correspond to relative frequencies over the total number of introduced species. The adjacent tables show the relative frequencies of the species origins.

Spain by man because of their economic applications, whether as ornamental plants (for instance, *Reynoutria japonica* Houtt), green forage (*Atriplex semibaccata* R. Br.), green manure (*Phacelia tanacetifolia* Bentham), or for land reclamation (*Chloris virgata* Swartz, *Chloris gayana* Kunth).

Non-native species deliberately introduced for cultivation and then accidentally naturalized in Spain represent 27,5% of our catalogue. The reason for their introduction was their economic application, that can be divided into: ornamental uses (31 species ⇔ 19%), land reclamation (14 species ⇔ 8,5%) and others (5 species ⇔ 3%). Some of these species had several uses.

There is also the case of introduced species that have a very restricted area of distribution as naturalized species, for example, *Narcisus calcicola* Mendonça and *Androsace helvetica* (L.) All. Their distribution is assumed to be a result of their natural dispersal capacity.

The relative frequencies of the places reported as first records for the Spanish Iberia are given in Figure 3. The tables presented as attachments to Figure 3 show the relative frequencies of the species origins. From this Figure 3 it can be inferred that the autonomous regions most affected – in terms of relative frequencies – by the introduction of non-native species are Andalucia (24,9%), Valencia (18,9%) and Catalonia (16,4%).

Conclusions

The results of this work show that the number of non-native species introduced in the